

Lesson 6

Evaluate

Environmental Hazards

Overview

Students use the knowledge they have gained from previous lessons to solve a problem depicted in a fictional scenario. In the scenario, students participate in a field trip to a natural history museum. Upon returning to the school, many participants complain of headache and nausea. Students consider the potential chemical exposures experienced by the field-trip participants and analyze who was exposed, how they were exposed, and how much exposure they experienced. Using fact sheets to learn about the specific hazards and health reactions attributable to certain chemicals, students solve the problem and recommend ways that the participants could have minimized or eliminated their exposure.

Major Concepts

People can use their understanding of the science of toxicology to identify potential sources of harm to human health from chemicals in the environment. They can use their knowledge to propose possible means to eliminate or reduce exposure to environmental toxic agents.

Objectives

After completing this lesson, students will

- be able to identify potential sources of harm to human health from chemicals in the environment;
- be able to apply their knowledge about dose, response, route of exposure, and individual susceptibility to situations involving potentially hazardous chemical exposures; and
- propose possible means to eliminate or reduce exposure to environmental toxic agents.

Protecting Human Health

Decisions about chemical exposures occur at different levels. For example, a person can choose whether he or she wants to consume caffeine. In other cases, an individual is not able to control a chemical exposure simply by making a personal decision. For example, while a person might choose not to smoke in order to avoid exposure to the chemicals in tobacco smoke, he or she sometimes is unable to avoid secondhand smoke.

Sometimes there are larger social, economic, and political forces involved in hazardous exposure at a community level. As a result, organizations and agencies, including different levels of government, often become involved in prevention of chemical exposure and intervention when people suspect chemical exposure. For example, regulations made at a community level can minimize the exposure of members of the community to secondhand smoke in public places.

At a Glance

Background Information

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On a national level, many organizations are concerned with protecting and improving human health. The **Department of Health and Human Services** is the U.S. government's principal agency for protecting the health of all Americans. Within the Department of Health and Human Services operate many different divisions. The **National Institutes of Health (NIH)** is the world's premier medical research organization. Among its many institutes and centers is the **National Institute of Environmental Health Sciences (NIEHS)**, whose mission is to reduce the burden of human illness and dysfunction from environmental causes by understanding how environmental factors, individual susceptibility, and age interrelate. The NIEHS achieves its mission through multidisciplinary biomedical research programs, prevention and intervention efforts, and communication strategies that encompass training, education, technology transfer, and community outreach.

The mission of the **Agency for Toxic Substances and Disease Registry (ATSDR)** is to prevent adverse effects on human health and diminished quality of life associated with exposure to hazardous substances from waste sites, unplanned releases, and other sources of pollution present in the environment. The ATSDR is directed by congressional mandate to perform specific functions concerning the effect on public health of hazardous substances in the environment. These functions include public health assessments of waste sites, health consultation concerning specific hazardous substances, health surveillance and registries, response to emergency releases of hazardous substances, applied research in support of public health assessments, information development and dissemination, and education and training concerning hazardous substances.

The **Food and Drug Administration (FDA)** ensures that the food we eat is safe and wholesome, the cosmetics we use don't hurt us, the medicines and medical devices we use are safe and effective, and radiation-emitting products such as microwave ovens won't harm us. Feed and drugs for pets and farm animals also come under FDA scrutiny. The FDA also sees that all of these products are labeled truthfully with the information that people need to use them properly. First and foremost, the FDA is a public health agency, charged with protecting American consumers by enforcing the Federal Food, Drug, and Cosmetic Act and several related public health laws. Investigators and inspectors visit more than 15,000 facilities a year, checking that products are made correctly and labeled truthfully. On average, 3,000 products a year are determined to be unfit for consumers and are withdrawn from the marketplace. In addition, about 30,000 import shipments a year are detained at the port of entry because the goods appear to be unsafe.

In addition to divisions of the Department of Health and Human Services, there are other government agencies for the communal protection of health. The mission of the **U.S. Environmental Protection Agency (EPA)** is to protect human health and to safeguard the natural environment—air,

water, and land—upon which life depends. The EPA's purpose is to ensure that

- all Americans are protected from significant risks to human health and the environment where they live, learn, and work;
- national efforts to reduce environmental risk are based on the best available scientific information;
- federal laws protecting human health and the environment are enforced fairly and effectively;
- environmental protection is an integral consideration in U.S. policies concerning natural resources, human health, economic growth, energy, transportation, agriculture, industry, and international trade, and these factors are similarly considered in establishing environmental policy;
- all parts of society (communities, individuals, business, state and local governments, tribal governments) have access to accurate information sufficient to participate effectively in managing human health and environmental risks;
- environmental protection contributes to making our communities and ecosystems diverse, sustainable, and economically productive; and
- the United States plays a leadership role in working with other nations to protect the global environment.

Part of the U.S. Department of Labor is the **Occupational Safety and Health Administration** (OSHA). The mission of OSHA is to save lives, prevent injuries, and protect the health of America's workers. To accomplish this, federal and state governments work in partnership with the more than 100 million working men and women and their employers to comply with the Occupational Safety and Health Act of 1970. OSHA currently regulates exposure to approximately 400 substances present in the workplace that are capable of causing harm. Together with the **National Institute for Occupational Safety and Health** (NIOSH), which is part of the **Centers for Disease Control and Prevention** (CDC), OSHA provides guidelines about chemicals, including chemical and physical properties, health effects, exposure limits, and recommendations for medical monitoring. These guidelines summarize pertinent information about chemicals for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs.

The **U.S. Department of Agriculture** (USDA) has agricultural toxicology regulatory authority, and the **Food and Nutrition Service** (FNS) participates with the CDC on food safety issues.

Notes About Lesson 6

In Lesson 6, students analyze a fictional situation in which members of a class are exposed to a chemical that makes them sick. While they investigate several scenarios in which individual behavior increased the risk of chemical exposure, students recognize that the actual cause of the sickness in the scenario is

Chemicals, the Environment, and You: Explorations in Science and Human Health

carbon monoxide poisoning caused by a faulty exhaust system in a school bus. Because the maintenance of the bus is a school district responsibility, and not an individual one, the exposure of students to carbon monoxide is not one over which the exposed students had control. Students see that there are various regulations, agencies, and organizations in place to protect them as citizens from chemical exposure over which they have little control. It is important, however, for students to recognize that they have the right, as citizens of their school, community, nation, and the world, to seek direct input into how to reduce the extent of chemical exposure on a communal level.

As the Evaluate lesson for the curriculum supplement, Lesson 6 offers students the opportunity to express their understanding of the concepts in the supplement in a new context. As students share and compare their ideas with those of others, they can refine and revise them. As you listen to them reasoning out loud, you can assess their individual understanding of human health and the environment.

This lesson is not the only opportunity you have had to assess your students' progress. As noted in each of the previous lessons, assessments have gone hand in hand with instruction throughout the supplement. Whenever individual students expressed themselves by talking, writing, or performing tasks, you have had an opportunity to assess their thinking and thus their learning. The assessment tasks are embedded within the lessons and offer you the opportunity to

- determine students' initial understanding of concepts to be learned,
- determine students' initial familiarity with processes and their ability to use them,
- monitor students' conceptual development and ability to use certain processes and skills, and
- collect information about students' achievement of the outcomes of each lesson and of the supplement as a whole.

The approach to assessment in this supplement is congruent with the following recommendations in the *National Science Education Standards*.¹

- Assessment tasks are deliberately designed.
- Assessment tasks have explicitly stated purposes.
- Assessment data focus on the science content that is most important for students to learn.
- Assessment tasks are valid and authentic.
- Students have adequate opportunities to demonstrate their achievements.
- Assessment tasks are set in a variety of contexts.
- Assessment tasks include opportunities for students' self-assessment and reflection.

CD-ROM Activities	
Activity Number	CD-ROM
Activity 1	yes
Activity 2	no

Photocopies		
Activity Number	Master Number	Number of Copies
Activity 1	Master 6.1, <i>Heads or Tails?</i> Master 6.2, <i>Choice Cards</i> Master 6.3, <i>Fact Sheets on Chemicals</i>	1 for each student (optional) 1 Choice Card for each student (optional) all pages in the set, at least 5 sets (optional)
Activity 2	none	none

Materials	
Activity 1	Activity 2
For the class: <ul style="list-style-type: none"> • CD-ROM • computers • 5 sets of fact sheets, copied from Master 6.3, <i>Fact Sheets on Chemicals</i> (optional) • 1 red marker (optional) For each student: (if using Print version) <ul style="list-style-type: none"> • 1 coin • 1 copy of Master 6.1, <i>Heads or Tails?</i> • 1 Choice Card, copied from Master 6.2, <i>Choice Cards</i> 	For each student: <ul style="list-style-type: none"> • 1 copy of completed <i>Heads or Tails?</i> sheet, Master 6.1, from Activity 1 (optional)

PREPARATION

Activity 1

Decide whether you will use the CD-ROM or print version of this activity. If you choose to use the CD-ROM version, which is preferred, arrange for students to have access to computers.

If you use the print version, gather the materials needed to conduct the activity. Duplicate Master 6.1, *Heads or Tails?*, 1 for each student. Copy Master 6.2, *Choice Cards*, and cut apart the cards, making enough for each student to have one card.

Make at least 5 sets of the 6 fact sheets in Master 6.3, *Fact Sheets on Chemicals*. Fold each fact sheet in half. Label the outside of each sheet with the location from the scenario. Place the sets of fact sheets on a desk in the front of the room.

Activity 2

If you used the print version of Activity 1, students need their completed copy of Master 6.1, *Heads or Tails?*

Procedure



Content Standard A:
Students should develop abilities necessary to do scientific inquiry.



Circulate around the room, listening to students as they solve the problem presented on the CD-ROM. Listen to see if students are using the language of toxicology: chemical, dose, response, individual susceptibility, and route of exposure.



Content Standard A:
Students should develop abilities necessary to do scientific inquiry.

ACTIVITY 1: THE FIELD TRIP

The following procedures describe how to conduct the CD-ROM version of this activity. Instructions for the print version follow.

1. Gather students in the computer lab and direct them to work with a partner for this CD-ROM activity.



This activity can be completed using the segment titled *The Field Trip* on the CD-ROM. Direct students to go to the main menu and click on *Environmental Hazards*.

2. Instruct students to work through the problem posed on the CD-ROM using the available resources, records, and data.
3. Once all teams have reached a conclusion about the cause of the illness on the field trip, conduct a class discussion during which teams present their conclusions and their supporting evidence.

Because most students should reach the same conclusion (that a faulty exhaust system in the old yellow bus created carbon monoxide in high enough concentrations to poison some of the students), encourage teams to share one piece of evidence they used to come to their conclusion. Then, let other teams add to the picture of carbon monoxide poisoning, or share evidence for why another chemical exposure probably did not contribute to the illness of the students. In this way, all students have an opportunity to share new ideas.

4. To complete the discussion of the field trip, go to Activity 2.

Print Version

If you do not have access to computers to conduct the CD-ROM version of this activity, use the following print version of Activity 1.

1. Tell students that today they are going to participate in a re-creation of a field trip to a natural history museum. To let them know what the field trip was like, read to them the journal entry from one of the participants on the field trip (see page 107).
2. Distribute to each student one copy of Master 6.1, *Heads or Tails?* Tell students that they are going to determine their actions on the field trip based on a coin toss. For each action, if they get heads, they will check the box for the action on the left-hand side of the page. If they get tails, they will check the box for the action on the right-hand side of the page.
3. Next, distribute one Choice Card to each student. Tell students that they can use the Choice Card to overrule one of their coin flips if they would rather choose the opposite action.

Today, we went with our whole class to the Museum of Natural History. It was a cool trip! So much happened that I want to remember, so I am going to write it all down here. First, we all loaded up in the new blue passenger van—you know, the one that the school just bought. It was awesome. The seats are like airline seats and they even have seat belts. We didn't have to squish three into a seat like we do in the old bus. My friends and I rushed to get the back of the van—it's better there because we can have the most fun. We had to stop at the gas station to fuel up the van, so we stuck our heads out of the windows in the back and talked to the driver as he filled the tank. I guess we distracted him, because he overflowed the tank and some gas spilled on the ground. Oops! Gasoline sure stinks! Finally, we got back on the road. When we got to the museum, we got a special tour by a paleontologist. She showed us the lab where fossil exhibits are prepared. We stood outside the window and watched the scientists build a model of a dinosaur out of fiber glass and plywood. All the people in the lab wore respirators because I guess there are lots of chemicals in use in there—at least there was a sign on the door that said, "Caution! Chemicals in Use. Authorized Personnel Only." Then, without even reading the sign, a couple of kids from the class opened the door and went into the lab! Our guide seemed shocked. She pounded on the glass to get a scientist's attention. A scientist saw the students and hurried them back to the door. I think they got yelled at, but it was hard to tell what the scientist was saying through the respirator. Boy, did they get in trouble from the teacher!

When it was lunch time, we got to eat our sack lunches in the picnic area. It was a neat, big atrium with a really tall glass ceiling. A treat from the teachers was that each of us got to drink a soda that they brought in a big cooler. It was really too bad that they didn't have more root beer or lemon-lime soda because the new kid had to drink a *caffeinated* soda because that was all that was left—and she really isn't supposed to drink it because of some problem she has with caffeine. I would have shared mine with her, but I already took a sip from it.

After lunch they planned for us to go into the hands-on activity room. We got to paint plaster models of dinosaurs. What a mess we made. Some kids got paint all over their skin and needed to wash it off at the sink. We got sort of wild by the time we finished the project, and I think our teachers were ready to get us back to school.

When we went outside the museum, we saw the old yellow bus there to pick us up. My friends groaned—no more plush seats and clean windows. I never feel as safe in the old bus because there aren't seat belts, so I sat in the front of the bus going back to school, squished into a seat with two other people. I sure was glad to get to the school. The funny thing was that we weren't nearly as noisy going home as we were going to the museum. I guess we were tired. It was a fun day anyway.

4. Give each student one coin. Proceed as a class through the *Heads or Tails?* worksheet, one action at a time. Ask students to record the results of their coin toss by checking the appropriate box on the sheet. Remind students that they can use their Choice Card for one turn to choose the opposite action.



5. After all the students have completed the worksheet, announce that some of the members of the class got sick after the field trip and ended up going to the emergency room with their parents because they had severe headaches and nausea. Circulate around the room looking at all the students' sheets. With a red marker, write the words "Sick" or "Not Sick" on the top of each sheet.

Mark "Sick" on the worksheets if the student marked "you sat in the back of the yellow bus" (got heads in the coin toss for the last action). If the student marked "you sat in the front of the yellow bus" (got tails for the last action), then the student is not sick. Do not let the students know that you are looking only at the last action: Make it look like you are studying all the actions for the trip to decide if the student is sick.

Tip from the field test: To make the discussion more interesting and the problem harder and less obvious to solve, mark one or two students sick who did *not* sit at the back of the yellow bus. These students represent individuals who have higher susceptibility to carbon monoxide even though they did not sit in the back of the bus nearest to the faulty exhaust system. More-susceptible individuals would be affected by a lower concentration of carbon monoxide.

6. Discuss the problem of some students getting sick by asking these questions:
 - Why do you think some of the students got sick?

Answers will vary, but try to get students to recognize that some students might have been exposed to chemicals during the field trip.

- **To what chemicals could students have been exposed during each of the parts of the field trip?**

Conduct a brainstorming session with students of possible chemical exposures:

- * Ride in new van: “new car smell” from new carpet and seat fabrics, exhaust fumes
- * Gas station: gasoline fumes
- * Paleontology lab: fiber glass dust, plywood fumes
- * Lunch: caffeine in soda, food poisoning from sack lunches
- * Painting activity: paint on the skin, cleanup solvents
- * Bus ride in the old bus: gasoline fumes, exhaust fumes



- **Why didn't all of the students get sick?**

Answers will vary. Some students might not have been exposed to chemicals because their actions were different. Some might not be susceptible to the chemicals that made other students sick.

- **How would you figure out what made some students sick while others remained healthy?**

Answers will vary. Accept possible strategies before moving to Step 7. Students might suggest comparing sick students' actions to the actions of students who did not get sick. Propose this strategy if students do not mention it.

7. Ask each student who is sick to pair up with a student who is not sick.

Statistically, you should end up with nearly an equal amount of sick and healthy students. If the numbers are not even, make a few groups of three students.

Tell students that you want them to figure out what made one student sick in each pair. Ask students to work with their partners to determine what actions and chemicals could have caused the sickness in their pair.

Chemicals, the Environment, and You: Explorations in Science and Human Health

Students will realize that they can compare the actions each took on the field trip. If there are actions that the sick student did that the other student did not do, students might hypothesize that those actions put the sick student more at risk of exposure to certain chemicals.

8. Ask the students what information they need to solve the problem of what caused the sickness in some students.

Help students realize that they need more information about the kinds of chemicals to which students were exposed and the symptoms caused by each.

Show students the sets of fact sheets at the front of the room. Tell the students that each fact sheet contains information about chemicals to which some students were exposed at specific locations during the field trip. Instruct students to go to the front of the room and select one fact sheet the pair would like to study based on their determination from Step 7 of what actions and chemical exposures might have caused the sickness. They can return that fact sheet and select another if time allows.

Direct students to read the information on the fact sheet, discuss it with their partner, and decide whether the chemical in the location could have caused the sickness.

Students should consider the chemical, the route of exposure, the dose, and the symptoms that a person exposed to the chemical exhibits.

When they read the fact sheet, they may determine that the chemicals to which they were exposed in a certain location could not have caused the illness because there was not enough chemical there, the dose they might have received was too little, or the symptoms of the sick people do not match those produced by exposure to the chemicals.

Students probably will have more than one possible location of chemical exposure to check. They will need to study all the possible locations and chemicals to determine which one might have caused the sickness. It is possible that they may not be able to decide between two possibilities until the class meets together and compares notes.

9. Once students have come to some conclusions about the possible cause of sickness, discuss their solutions with the whole class.

There are two ways to figure out why some students became sick. The first is by the process of elimination. Help students narrow the possible chemicals that caused illness by determining how many of the sick students were exposed to chemicals at each location. Compare the total number of sick students with those sick students who were involved in actions at the various locations. For example, if the total number of sick students was 15, but only six sick students drank caffeine, what conclusions can students draw?

From the discussion, students can see that all the students who sat at the back of the yellow bus became sick, while students who took part in each of the other actions were not universally sick. Ask the sick students how many were *not* sitting at the back of the yellow bus. Only those few students you purposely marked sick (if you chose to) should reply. Explain their illness in the context of individual susceptibility to chemical exposure.

The second way to figure out what made the students sick is to study the fact sheets. In all cases except carbon monoxide, the exposure the students received to the chemicals in each location is insignificant. Students can see that, even though there might be chemicals present in various locations or associated with various activities, their health is not at risk when they are exposed at the levels that were present on the field trip. Being able to recognize that an exposure to a chemical is not at a level that causes harm is an important part of the risk assessment process.

Students will make the correlation between sitting in the back of the yellow bus and carbon monoxide poisoning by referring to the fact sheets. They will reach the conclusion that the sick students were suffering from carbon monoxide poisoning, which was caused by a faulty exhaust system in the old yellow bus. Those in the back of the bus were exposed to more carbon monoxide than those in the front of the bus. Those who got sick who were sitting in places other than the back of the bus must be more sensitive to carbon monoxide than average.

10. To complete the discussion of the field trip, go to Activity 2.

ACTIVITY 2: WHAT CAN I DO?

1. Ask students whether some of the students on the field trip made choices that either limited or increased their exposure to chemicals on the museum field trip. Discuss how the choices the students on the field trip made are similar to decisions that they make in their own lives.

Students who did the CD-ROM version of the activity can refer to the records on the CD-ROM to find out how exposure to the chemicals present at the field trip locations can be avoided.

If students did the print version of Activity 1, ask them how their use of the Choice Cards simulated decisions they make in their own lives that influence their exposure to chemicals.

Informed citizens can make decisions to limit or eliminate their exposure to environmental hazards. They can alter their lifestyles, their work, their use of materials that are made of hazardous chemicals, and so on.

2. Discuss with students that the cause of the sickness in some of the field-trip students was related to a situation over which the students had no control. Ask students what they think they would be able to do about the faulty exhaust system in the bus. Go one step further and ask students what they think they can do about chemical exposure on a community level.



To assess your students' understanding of individual susceptibility, ask them to explain what could have happened to those few students who did not sit at the back of the bus but were sick anyway.



Content Standard F: Students should develop understanding of personal health, natural hazards, and risks and benefits.

Chemicals, the Environment, and You: Explorations in Science and Human Health

Some choices are not left to the individual because the decisions are made at a community or national level. For example, people could be at risk of exposure to radiation when they live near a nuclear power plant even if they do not support the decision to use nuclear energy to produce power. In the scenario in this activity, students did not know that the yellow bus had a faulty exhaust system, so they were unable to decide to limit their exposure to carbon monoxide. In response to the situation with the bus, students could write letters to their superintendent, petition the school for stricter safety standards, or raise money to support a better maintenance program. Share with students information about the various organizations and agencies whose mission it is to protect human health (see *Background Information*). Encourage students to investigate the organizations by logging onto the following Web sites:

- U.S. Department of Health and Human Services
<http://www.hhs.gov>
- National Institutes of Health
<http://www.nih.gov>
- National Institute of Environmental Health Sciences
<http://www.niehs.nih.gov>
- Agency for Toxic Substances and Disease Registry
<http://www.atsdr.cdc.gov>
- U.S. Food and Drug Administration
<http://www.fda.gov>
- U.S. Environmental Protection Agency
<http://www.epa.gov>
- U.S. Occupational Safety and Health Administration
<http://www.osha.gov>
- National Institute for Occupational Safety and Health
<http://www.cdc.gov/niosh>
- Centers for Disease Control and Prevention
<http://www.cdc.gov>
- U.S. Department of Agriculture and Food and Nutrition Service
<http://www.usda.gov>